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NRL 13 MICRON HIGH POWER SINGLE ELEMENT LASER DIODE(U)
TRW SPACE AND TECHNOLOGY GROUP REDONDO BEACH CA APPLIED
TECHNOLOGY DIV OCT 87 TRW-NR-9 N00014-86-C-2586

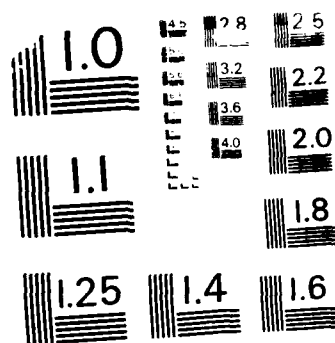
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MICROCOPY RESOLUTION TEST CHART
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NRL 1.3 MICRON HIGH POWER
SINGLE ELEMENT LASER DIODE

Contract No. N00014-86-C-2586
Monthly Report No. 9, October 1987

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As discussed in last month's technical report (Monthly Report No. 8, September 1987), an examination of the characteristics of devices which we have made indicate several problems. Slope efficiencies (η_d) are low, averaging between 0.20 and 0.30 mW/mA for our devices. Optimal expected values are in the 0.35 to 0.40 mW/mA range. Also, the far-field characteristics of most devices show multiple-lobed structures, indicative of interference of radiation from several sources. There are some devices with stable, smooth far-field patterns, but they are a minority. To analyze this problem, devices with no facet coatings had their far-field characteristics measured and then underwent SEM analysis of the device's cross-section as viewed from the front-facet. The SEM micrographs were attached to the far-field plots and a comparison was made across several devices. The SEM micrographs reveal extraneous and irregular crystal growth (of the epitaxial layer which forms the active region) along the walls of the V-channel. SEM micrographs of every device which showed this anomalous crystal growth on the walls of the V-channel correspond to far-field patterns which are characterized by multiple lobes.

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Such extraneous growth of the epitaxial layer that makes up the active region is primarily caused by crystal growth on random nucleation sites that would occur if an oxide layer is formed on the walls of the V-channel after etching of the channel or during the wafer preparation (cleaning) prior to regrowth (the crystal growth which fills the channel). Such uneven crystal growth of the active region would be a source of leakage currents and/or extra lasing filaments which affect both the device efficiency and the far-field characteristics. Even if no active-layer islands would be grown, the buried oxide layer would still give rise to non-radiative recombination of carriers, again influencing the device efficiency.

Present activities, therefore, are aimed at refining the processing and crystal growth procedures to eliminate the extraneous and anomalous features. Our efforts are carried out along three parallel paths as illustrated in Figure 1. We have pursued some improvements in processing which include refinements of the channel etching step and a dehydration (oven bake-out) of the SiO_2 used for the channel etching mask. These refinements have improved the uniformity and reproducibility of the channels across the wafers, but have not provided the overall remedies to the problems of low efficiencies and poor far-fields.

The other two paths indicated in Figure 1 are related to the crystal regrowths, the step in which the channels are filled with epitaxial material and the active layer is grown. The first of these paths is concerned with the preparation of the wafer just before it is loaded into the crystal growth reactor. The focus of effort here is on the elimination of the O_2 -plasma step in

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which has been used to remove residues of the photolithography process. Preliminary results indicate that there is no acceptable substitute for a total elimination of the O₂ plasma step. As an alternative, we are including measures after the O₂ plasma step to eliminate any oxide layer which may have been formed during the O₂ plasma etch without altering the uniformity and shape of the channels. These measures include an argon sputtering step or an HF soak. We are currently examining the results of the second of these measures.

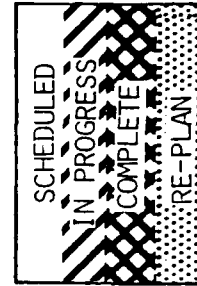
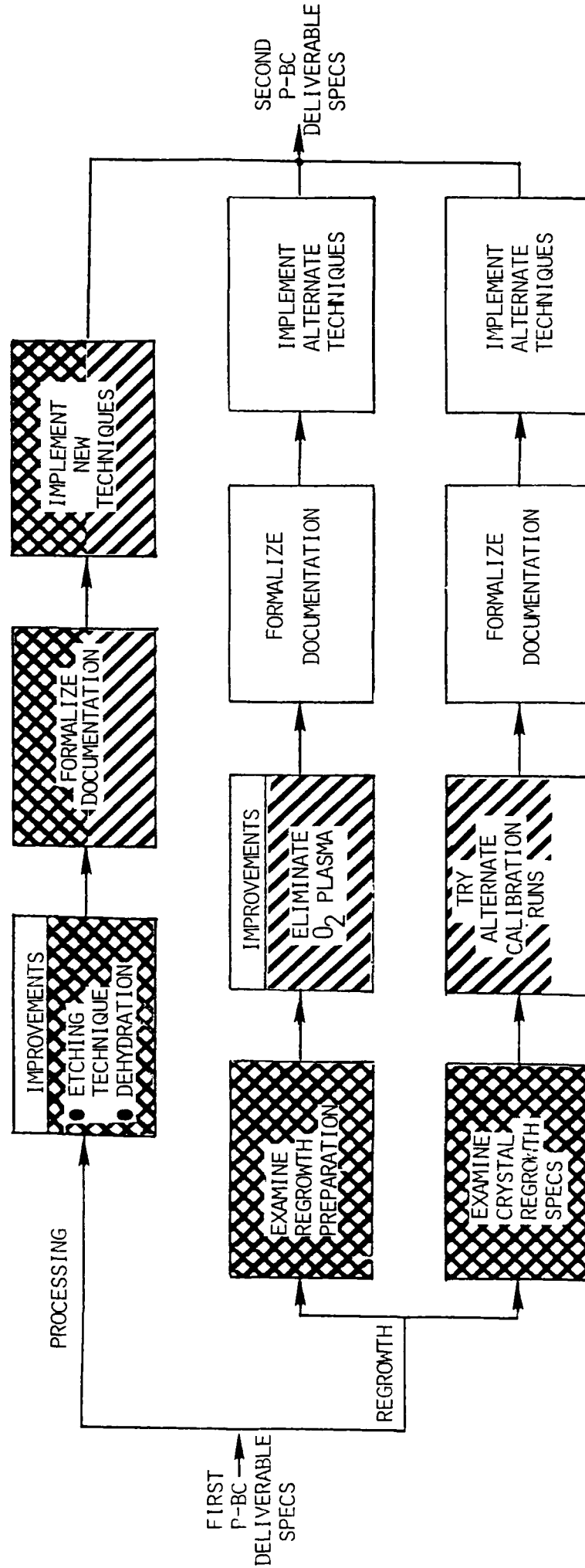
In the final path, we are reexamining the actual crystal regrowth specifications to see if alternative parameters might produce better results. However, we are currently only at the preliminary stages of pursuing this path.

The pursuit of these three paths is in progress and the results will be forthcoming.

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